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REFRACTIVE SURGERY

Visual outcomes of Femto-LASIK for correction of residual refractive error after corneal graft

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Abstract
Purpose To evaluate the outcomes of the Femto-LASIK method in the treatment of refractive errors following penetrating keratoplasty (PK) at the Persian Eye Clinic, Isfahan, Iran
Methods In a prospective, non-comparative case series, 34 consecutive symptomatic eyes of 34 patients after corneal graft, were operated on. Tissue-saving (TS) Femto-LASIK ($n=16$), and Zyoptix Personalized Treatment Advanced (PTA) Femto-LASIK ($n=18$) were performed using the Bausch & Lomb Technolas 217z excimer laser and Zyoptic algorithm. Uncorrected visual acuity (UCVA), best-corrected visual acuity (BCVA), manifest refraction, contrast sensitivity, and HOAs were evaluated preoperatively and 12 months after enhancement treatment.
Results At 12 months, the mean preoperative myopic spherical equivalent refraction (SE) decreased from −6.50±2.8 D to −1.6±1.8 D, and mean hyperopic SE from +3.2±2.20 D to 0.37±1.2 D. The safety index was 1.42 (1.2 in the TS group and 1.5 in the PTA group). In the TS group, 100 % of eyes achieved 20/80 or better UCVA and 50 %, 20/40 or better and in the PTA group, 100 % of eyes achieved 20/80 or better UCVA and 77.7 %, 20/40 or better. The efficacy index was 1.08 (0.9 in TS group and 1.21 in the PTA group). Patients obtained statistically significant lower values of root mean square (RMS) of HOAs with spherical aberrations ($p<0.05$).
Conclusions Femto-LASIK method with Zyoptic programs after PK was safe, effective, and predictable for correction of spherical and cylindrical components of the refractive error.

Keywords Corneal graft · Tissue saving · Personalized Treatment Advanced · Femto-LASIK

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Introduction

Visual rehabilitation after penetrating keratoplasty remains challenging. The presence of astigmatism and other ametropia is a major hurdle in the visual rehabilitation of patients who have undergone penetrating keratoplasty. They often cannot be corrected by spectacles due to aniseikonia, therefore surgical approaches are of interest. Surgical methods to improve astigmatism following penetrating keratoplasty (PK) include continuous suture adjustment [1], selective suture removal [2], compression sutures [3], wedge resection [4, 5], transverse keratotomies, augmentation sutures [6, 7], and more recently the use of excimer laser photorefractive surgery. Laser in situ keratomileusis (LASIK) is a widely accepted method for treating a great range of refractive errors and has been successfully used in treating patients requiring refractive surgery after PK as well [8–13].

Laser instruments differ in delivery platform, software design, ablation profile, and treatment zones and treat varying types of higher-order aberration (HOA), which could have a measurable impact on visual performance [14]. Femtosecond thin-flap LASIK or Femto-LASIK has been shown to safely and effectively reduce postoperative refractive error (in particular the spherical component) in patients who have previously undergone PK [15]. The purpose of this prospective study was to

evaluate the 12-month postoperative visual outcomes of Femto-LASIK method with the Zyoptic algorithm using a scanning-spot 217z excimer laser (Bausch & Lomb) for residual refractive error after penetrating keratoplasty.

Patients and methods

Patients

Thirty-seven eyes with residual astigmatism and ametropia following penetrating keratoplasty that could not be adequately corrected by contact lenses or spectacles were assessed for LASIK and underwent Femto-LASIK with tissue-saving method or Femto-LASIK with Personalized Treatment Advanced (PTA) between March and December 2011. The study protocol was approved by the ethical committee of Isfahan University of Medical Sciences. Three patients who failed to attend all the visits and undergo all the clinical examinations required were excluded from this study. Out of the 34 patients studied, 12 were male and 22 were female. Twenty-three grafts had been performed for keratoconus, two for Fuchs endothelial dystrophy, five for posttraumatic scares, and four for pseudophakic bullous keratopathy.

The average age of the patients at the time of LASIK was 32 years with a range of 21–49 years. Corneal graft sizes ranged from 7.0 to 8.5 mm (mean, 8 mm). The mean interval between penetrating keratoplasty and LASIK was 8 years and 11 months, with a range of 1 year and 11 months to 23 years and 2 months. All eyes had had the graft sutures removed a minimum of 10 months before LASIK.

A full ophthalmological examination was performed on all patients prior to surgery, including uncorrected visual acuity (UCVA) and best-corrected visual acuity (BCVA) (were tested with the Snellen chart), manifest and cycloplegic refraction, slit-lamp examination with fundus evaluation, corneal topography (Orbscan II z, version 3.10.31, Bausch & Lomb), wavefront assessment Zywave (Wavefront Analyzer, Wavelight), ultrasonic pachymetry. Informed consent was obtained from all patients after a thorough explanation of the two procedures and their potential benefits and risks.

Careful slit-lamp microscopy was performed throughout the 360° of the graft host junction to ensure that there was no posterior graft-host junction gape, anterior-posterior displacement, or uneven wound healing before inclusion for treatment. The corneal radiuses of curvature were measured by the Orbscan II topographer, which operates on the principle that light rays. Three Orbscan II maps were taken, and the one with the least eye movements was used. The maximum movements considered acceptable were 200 μm. Exclusion criteria included heavily vascularized corneae, simulated keratometry readings below 38 diopters (D) or greater than 55 D, anterior posterior misalignment of the graft–host junction of greater than an estimated 10 %, and internal gaping of the graft host junction of greater than 20 % of corneal thickness. The treatment goal was primarily to reduce the refractive error to a great extent and not necessarily emmetropia, since the preoperative refractive disorders were quite high.

Surgery

Sixteen patients underwent Femto-LASIK treatment with tissue-saving method (TS group) and 18 patients underwent Femto-LASIK with Personalized Treatment Advanced (PTA group).

The Ziemer Femto LDV femtosecond laser was used to create the corneal flap for all the eyes. Selected flap diameter was 9 mm with superior hinge position, and flap thickness was 100 μm in all eyes. The decision of whether to perform TS or PTA technique was made based on preoperative aberrometry findings. Zywave aberrometry was tried in all patients. If a qualified aberrometry could be obtained, the patient was candidate for the PTA technique; otherwise the patient underwent the TS technique. The optical zone was set between 5.5 and 6 mm, according to estimated residual bed. The excimer laser platform used for the two groups was the Bausch & Lomb Technolas 217z.

All patients were operated on by a single surgeon. A residual stromal bed of 280 μm or more was left in all eyes. After surgery, all patients were given dexamethasone (0.1 %) every 2 h on the first day and four times daily for a week, ciprofloxacin every 4 h on the first day and four times daily for a week, and artificial tear artificial tears for 3 months. Postoperatively, the patients were seen at 1 day, 1 week, 1, 3, 6, and 12 months.

Data analysis

The main parameters evaluated in this study included visual parameters: manifest refractive spherical equivalent refraction (MRSE), astigmatism, UCVA, BCVA, and higher-order aberrations (HOAs). All parameters are expressed as means and standard deviation and were analyzed using a t test with software program SPSS (version 15.5, SPSS Inc., Chicago, IL, USA). A p value less than 0.05 was considered statistically significant.

Results

The mean myopic spherical equivalent preoperatively was −6.5±2.8 (range, −11.38 D to −0.38 D) and mean hyperopic spherical equivalent preoperatively was 3.2±2.2 (range, 0.5–6.63 D). The mean preoperative astigmatism was −4.88±2.4 (−9.00 to 0.00 D). In 34 eyes the preoperative uncorrected visual acuity (UCVA) was 1.01±0.34. Preoperative best spectacle corrected visual acuity (BCVA) ranged between 20/200 and 20/20. Improvements in mean UCVA, BCVA, and higher-

order aberrations occurred in the tissue-saving LASIK and PTA LASIK groups at follow-up intervals (Tables 1 and 2).

The ablation depth per diopter of defocus equivalent was 11.9±5.2 m/D in the TS group and 19.1±10.1 m/D in the PTA group.

Intraoperative and postoperative complications such as wound dehiscence, buttonhole, partial flap, and graft rejection did not develop in this series of eyes.

Tissue-saving Femto-LASIK group

In the tissue-saving Femto-LASIK group (16 eyes), mean UCVA improved from 1.1±0.25 logMAR (range, 0.5–1.3 logMAR) to 0.36±0.19 logMAR (range, 0.00–0.7 logMAR) at 12 months, whereas mean BCVA improved from 0.32±0.24 log MAR (range, 0.0 to 1.00 logMAR) to 0.19±0.13 logMAR (range, 0.00 to 0.5 logMAR) at 12 months (Table 1). A statistically significant increase was noted in postoperative UCVA and BCVA at 1 and 12 months compared to the preoperative ($p=0.008$, and $p=0.008$, respectively). No eyes lost any lines of BCVA, six maintained their BCVA, four eyes gained one line, and others gained three or more lines. The mean gain at 12 months was 4.9 lines of UCVA and 1.9 lines of BCVA (Figs. 1 and 2). Refractive error for the TS Femto-LASIK group improved from sphere −3.39±4.1 diopters (D) (range, −8.75 to 6.25 D) to −0.51+/−1.9 D (range, −5.00 to + 4.00 D) (was significant $p=0.002$), and from cylinder −6.06± 2.2 D (range, −9.00 to −1.75 D) preoperatively to cylinder −2.37±1.4 D (range, −5.75 to 0.00 D) postoperatively at 12 months, with a significant difference for 1 and 12 months ($p=0.00006$ and $p=.04$, respectively (Table 1; Fig. 3). The axis between pre- and postoperative cylinder was within ±10°. Attempted versus achieved spherical equivalent (SEQ) refraction for the TS Femto-LASIK group can be seen in Fig. 4a (R2=0.86). Higher-order aberrations after TS Femto-LASIK decreased both with a 5- and 6-mm pupil, but this decrease was not statistically significant (Table 2).

PTA Femto-LASIK group

In the PTA Femto-LASIK group (18 eyes), mean UCVA improved from 0.88±0.37 logMAR (range, 0.25 to 1.3 logMAR) to 0.17±0.18 logMAR (range, 0.00 to 0.5 logMAR) at 12 months, and mean BCVA improved from 0.25±0.12 logMAR (range, 0.05 to 0.5 logMAR) to 0.05± 0.12 logMAR (range, −0.1 to 0.25) at 12 months. A statistically significant increase was noted in UCVA and BCVA at 12 months compared to the preoperative ($p=.0001$, $p=.002$) (Table 2). No eyes lost any lines of BCVA, five maintained their BCVA, and 13 eyes gained one or higher lines of BCVA. The mean gain at 12 months was 6.05 lines of UCVA and 3.2 line of BCVA (Figs. 1 and 2). In the PTA Femto-LASIK group, refractive error improved from sphere −2.02±4.5 D (range, −9.00 to 8.25 D) to 0.002±1.81 D (range, −4.25 to 2.25 D) at 12 months ($p=0.07$), and from cylinder −3.83±2.09 D (range, −6.75 to 0.00 D) preoperatively to −1.9±1.21 D (range, −4.5 to −0.25 D), reaching significance at 12 months postoperatively ($p=.0003$) (Table 2). The axis between pre- and postoperative cylinder was within ±1°. Attempted versus achieved spherical equivalent (SEQ) refraction for PTA Femto-LASIK group can be seen in Fig. 4b ($R^2=0.80$). Higher-order aberrations with and without spherical aberration decreased greatly and significantly after PTA Femto-LASIK with a 5- and 6-mm pupil (Table 2).

Discussion

High refractive errors are a frequent finding after PK [16–18] and reduce the patient's perception of success following corneal transplantation. High anisometropia impairs visual rehabilitation and compromises the patient's ability to return to normal binocular functions.

LASIK has been widely used since its inclusion in the clinical routine in the early 1990s to treat a great range of refractive disorders. By performing laser ablation in the

Table 1 Visual parameters in the Femto-LASIK ablation group before treatment and 12 months after treatment (mean ± SD)

Parameters		Pre-operative	Post-operative	*p* value
Cylinder (D)		−4.88±2.4	−2.1±1.3	0.00005
Spherical equivalent (D)	Myopic	−6.5±2.8	−1.6±1.8	0.0003
	Hyperopic	3.2±2.2	0.37±1.2	0.03
BCVA (-LogMAR)		0.28±0.19	0.12±0.14	0.0001
UCVA (LogMAR)		1.01±0.34	0.25±0.2	0.0001
RMS higher-order 5 mm		1.29±0.5	1.08±0.45	0.02
RMS HA w/o z400 5 mm		1.16±1.7	1.03±0.44	0.18
RMS total 5 mm		6.7±3.2	2.63±1.3	0.000
RMS higher-order 6 mm		2.45±1.2	1.97±0.84	0.33
RMS HA w/o z400 6 mm		2.18±1.06	1.82±0.82	0.18
RMS total 6 mm		10.58±4.9	4.4±2.1	0.000

BCVA best-corrected visual acuity, *UCVA* uncorrected visual acuity, *RMS* root mean square

Table 2 Tissue-saving Femto-LASIK and PTA Femto-LASIK outcomes

Parameters	TS group			PTA group		
Surgery type	Pre-op	Post-op	*p* value	Pre-op	Post-op	*p* value
Eyes per group, *n*	16	16		18	18	
Mean SE (D)	−6.4+/−3.8	−1.7+/−1.4	0.0000	−3.94+/−4.6	−0.98+/−2.2	0.003
Mean astigmatism (D)	−6.06+/−2.2	−2.37+/−1.4	0.0000	−3.83+/−2.09	−1.9+/−1.2	0.0000
BCVA (LogMAR)	0.32±0.24	0.19±0.13	0.04	0.25±0.12	0.05±0.12	0.004
UCVA (LogMAR)	1.1±0.25	0.36±0.19	0.00	0.88±0.37	0.17±0.18	0.000
RMS higher-order 5 mm	1.38±0.68	1.34±0.39	0.81	1.2±0.26	0.85±0.37	0.001
RMS HA w/o z400 5 mm	1.21±0.7	1.27±0.41	0.64	1.1±0.3	0.81±0.36	0.004
RMS total 5 mm	7.79±3.07	3.48±1.06	0.000	5.8±3.1	1.87±1.09	0.000
RMS higher-order 6 mm	2.49±1.3	2.4±0.77	0.85	2.23±0.52	1.5±0.67	0.004
RMS HA w/o z400 6 mm	2.1±1.3	2.22±0.8	0.82	2.09±0.56	1.45±0.66	0.009
RMS total 6 mm	12.91±4.9	5.59±1.6	0.0000	8.38±4.06	3.3±1.9	0.001

TS tissue-saving, *PTA* Personalized Treatment Advanced, *SE* sphere equivalent, *BCVA* best-corrected visual acuity, *UCVA* uncorrected visual acuity, *LASIK* laser-assisted in-situ keratomileusis

corneal stroma, postoperative wound healing reaction is very mild and the risk of scarring and haze formation is very low [19, 20].

LASIK combines a high patient convenience due to the lack of postoperative complaints and fast visual recovery with predictable, precise, and stable results. In addition, the rate of serious complications is very low [21, 22] due to the evolution of the hardware used and the standardized procedure, which makes LASIK the most frequently used mode of treatment in corneal refractive surgery.

Both microkeratome and Femto-LASIK have been shown to be effective in the correction of post-PK ametropia, particularly the spherical component [15]. To our knowledge, this is the first paper on the application of Femto-LASIK for ametropia correction in post-PK patients using the tissue-saving treatment or APT. This series has demonstrated that Femto-LASIK after a corneal graft can be a safe and effective procedure. Our mean reduction in spherical equivalent from −5.1 D to −1.32 D is comparable with the largest previously reported series where the spherical equivalent in those reaching 12 months' follow-up decreased from −10.06 D to −4.13 D [15, 23]. However, the preoperative refractive error is nearly twice as much in the TS group, which introduces a bias.

Our results show excellent safety indices (BCVA post/BCVA pre) of 1.42 in all patients and 1.2 and 1.5 in the TS Femto-LASIK and PTA Femto-LASIK groups, respectively. In addition, most eyes maintained their BCVA and some gained multiple lines of BCVA. Moreover, in the TS Femto-LASIK group, ten eyes (62.5 %) gained 1–6 lines of BCVA and in the PTA Femto-LASIK group 13 eyes (72 %) gained 1–6 lines of BCVA. Although two eyes in the PTA group

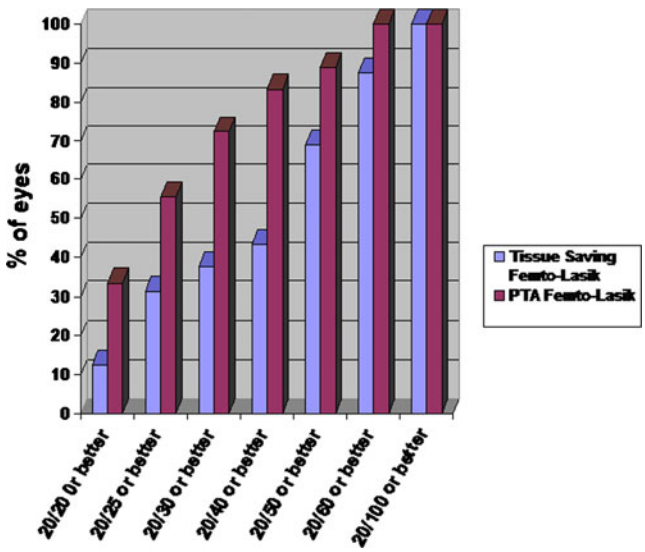

Fig. 1 Patients' UCVA 12 months after LASIK

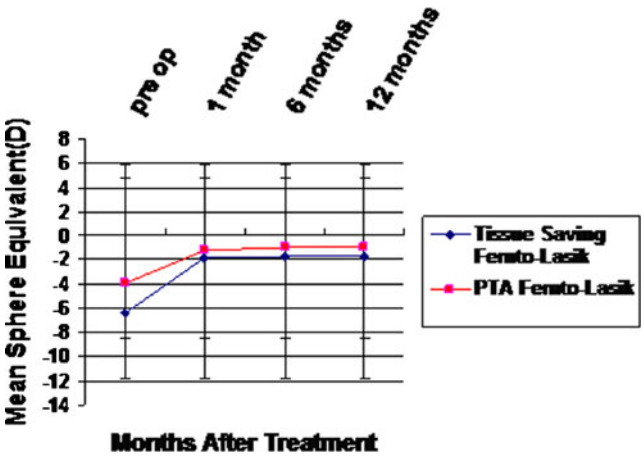

Fig. 2 Stability of spherical equivalent refraction (SEQ) over time after tissue-saving Femto-LASIK and PTA Femto-LASIK

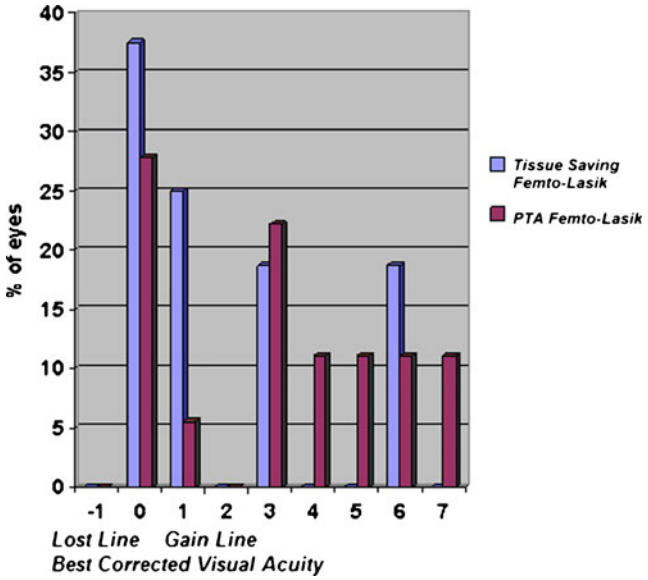

Fig. 3 Change in BCVA 12 months after LASIK

achieved a BCVA of 20/12, no super vision (visual acuity 20/10) was measured.

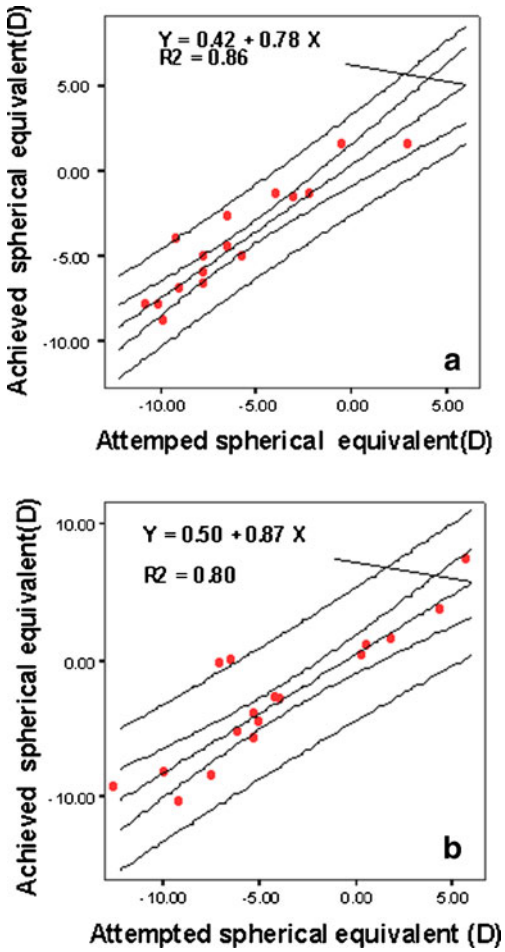

Fig. 4 Correlation between attempted and achieved spherical equivalent refraction (SEQ) at 12 months after tissue-saving Femto-LASIK (**a**) and PTA Femto-LASIK (**b**)

These findings are accordant with other studies [24–30], which have shown LASIK as an effective mode of treatment for refractive errors following PK.

Table 3 summarizes the results from studies that evaluated the efficacy and safety of LASIK for treatment of residual myopia or hyperopia in PKP eyes. Compared with these other studies, higher percentages of eyes in the present Femto-LASIK patients achieved UCVA of ≥_20/20 and ≥20/40.

Barequet et al. [15] performed Femto-LASIK in nine patients with ametropia after penetrating keratoplasty and showed a significant decrease in sphere and cylinder and a gain of ≥2 lines in BCVA in 33 % patients. Our study shows an improvement in UCVA after surgery for all eyes, with 100 % of eyes having UCVAs of 20/200 or better at 12 months (Fig. 1). Efficacy indexes were good in all patients; 1.21 in the TS Femto-LASIK group and 0.9 in the PTA Femto-LASIK group. Predictability was also good; in PTA Femto-LASIK group 83.3 % of eyes were within the ±1 D range in SE and in the TS Femto-LASIK group 68.75 %. The stability index at the 12-month period was excellent for all patients (0.08-D change of SE) (Fig. 3).

Preoperative SE in the TS Femto-LASIK group was −2.00 D more myopic than in the PTA Femto-LASIK group, and the measured ablation depth per diopter of defocus equivalent was 40 % less in the TS group. In our opinion, this tissue-saving effect of the Zyoptic treatment is a major advantage of this ablation technique. The resolution of anisometropia was the goal of LASIK in most patients in this study.

Many factors such as the size, curvature, and thickness of the corneal transplant, the underlying disease for the PK, preoperative refraction, the trephination technique, the type of suture, size and alignment of the corneal flap, whether the complete transplant is included in the lamellar flap or not, location of the hinge, the kind of microkeratome, and the settings used (advance rate, vacuum), the excimer laser and the chosen ablation profile as well as healing processes, which vary among patients affect the refractive outcome of LASIK after PK. The interactions between these factors are to a great extent still unknown.

It is reassuring that no eyes lost any lines of BCVA. Corneal scarring leading to the loss of three or four lines is a serious complication associated with photoastigmatic keratectomy [36–38].

A total of 64.7 % of eyes (77.7 % of eyes in PTA Femto-LASIK group and 50 % of eyes in tissue-saving Femto-LASIK group) achieved UCVA 20/40 or better at 12 months or later. The equivalent figure for normal corneas undergoing toric myopic LASIK is almost 80 % [39]. All eyes in this study achieved functional unaided acuity measuring 20/100 or better. We would like to suggest that unaided acuity should be included as an outcome measure in future reports of the refractive results of corneal transplantation (Fig. 1). Previous studies have failed to report uncorrected visual acuity results, possibly because they are generally not very good.

Table 3 Previous studies of LASIK outcomes following PKP

Study		Arenas et al. [9]	Donnenfeld et al. [26]	Forseto et al. [11]	Webber et al. [31]	Koay et al. [32]
Eyes		4	23	22	25	8
Pre-op error (D)		−10.75 (SE) −2.87 (Astig)	−7.58±4.42 (SE) 3.64±1.72 (Astig)	−4.55±3.66	−5.20 D (SE) 8.67 D (Astig)	−6.79±4.17 D (SE)
Post-op error (D		−2.37 (SE) −3.50 (Astig	−1.57±1.20 (SE) 1.29±1.04 (Astig)	−0.67±1.24	−0.24 D (SE) 2.48 D (Astig)	−0.64±1.92 D (SE)
Mean follow-up (months)		7 months	12 months	10.09±3.87 months	(18 eyes) 6 months or more	8.6 months
Post-op UCVA%	>20/20	n/a	n/a	n/a		
	>20/40	n/a	n/a	54.5 %	33.3 % of 18 eyes	n/a
Loss of BCVA	1 line	n/a	4.34 %	22.72 %	12 % of 25 eyes	0
	>2 lines	n/a	4.34 %		0	0
Eyes within desired refraction (%)	±0.50 D	n/a	n/a	n/a	n/a	43 %
	±1.00 D	n/a	n/a	72.7 %	n/a	57 %
Complications		n/a	None	None	1 eye surgical complication	n/a
Study		Nassaralla et al. [13]	Spadea et al. [33]	Rashad et al. [34]	Malecha et al. [35]	Kwitko et al. [27]
Eyes		8	4	19	20	14
Pre-op error (D)		−4.50 D (sph)	Case 1: −11, −4.5×85	−2.14±2.11 D (sph)	4.24±2.81 D (sph)	Myopia-5.33±4.22
		3.50 (Astig)	Case 2: −8	9.21±1.95 D (Astig)	4.05±1.71 D (cylinder)	Hyperopia 5.04±3.3
			Case 3: −4.5, −11×95			Astig 5.37±2.12
			Case 4: −4.5, −4×120			
Post-op error (D)		−0.75 D (sph)	Case 1: −1.00 , −2.5×70	0.43 ± 0.82 D (sph)	Mean sphere reduced by 3.93 D (80.0 %) and mean cylinder reduced by 2.83 D (69.9 %)	Myopia 0.19±1.71
		1.25 D (Astig)	Case 2: −0.5	0.50 ±1.75 (Astig)		Hyperopia 0.42±0.46
			Case 3: −0.5,3.5×100			Astig 2.82±2.42
			Case 4: 0.5			
Mean follow-up (months)		6 month	24, 18, 12, and 12	12 months	5 months	12 months
Post-op UCVA%	>20/20	n/a	20/50, 20/25, 20/50, and 20/25		n/a	Improved in 11 eyes (78.6 %)
	>20/40	n/a			73.7 %	
Loss of BCVA	1 line	0	0	0	BCVA remained within 1 line of preoperative visual acuity in 94.7 % of the eyes	35.7 %
	>2 lines	0	0	0		0 %
Eyes within desired refraction (%)	±0.50 D,	n/a	n/a	n/a	n/a	n/a
	±1.00 D	n/a	n/a	57.9 % of the eyes within ± 1.00 D of refractive astigmatism	n/a	n/a
Complications		n/a	None	None	None	Buttonhole flap (1 eye) epithelial ingrowth at (2 eyes) pseudophakic retinal detachment (1 eye)
Study		Hardten et al. [12]		Afshari et al. [8]	Barequet et al. [15]	Our study
Eyes		57		18	9	16 (TS Femto-LASIK) 18 (PTA Femto-LASIK)
Pre-op error (D)		−4.19±3.38 D (SE)		Myopic −5.86±2.74 D	Myopic −6.40+/−2.00	TS: -6.42±3.8

		4.67±2.18 (Astig)	Hyperopic −0.60±3.24	Hyperopic +0.80+/−2.80	PTA: -3.94± 1.1(4.6)
Post-op error (D)		−0.61 ±1.81 D (SE)	Myopic −1.23±1.56 D	Myopic −0.02+/−2.20 D	TS: -1.7±0.36 (1.4)
		1.94±1.35 D (Astig)	Hyperopic 0.48±0.94 D	Hyperopic −0.60+/−0.60 D	PTA:-0.98±0.52 (2.2)
Mean follow-up (months)		21.4±14.2 months	9.67 months	6 months	12 months
Post-op UCVA%	>20/20	n/a	9 %	n/a	TS: 12.5 %
					PTA: 33.3 %
	>20/40	43 %	36 %	n/a	TS: 43.25 %
					PTA: 83.33 %
Loss of BCVA	1 line	n/a	(17 %)	67 % of eyes were within 1 line of preoperative BCVA and 33 % gained> or =2 lines	TS: 0 %
	>2 lines	7 %	6 %		PTA: 0 %
Eyes within desired refraction (%)	±0.50 D	n/a	n/a	n/a	TS: 37.5 %
					PTA: 61.11 %
	±1.00 D	n/a	70 %	n/a	TS: 68.75 %
					PTA: 83.3 %
Complications		16 % epithelial ingrowth 9 % repeat corneal transplants	1 patient developed dehiscence of the keratoplasty wound	None	None

Astig astigmatism, *BCVA* best-corrected visual acuity, *LASIK* laser in situ keratomileusis, *SE* spherical equivalent, *UCVA* uncorrected visual acuity, *TS* tissue-saving, *PTA* Personalized Treatment Advanced

We found this procedure to be relatively free of complications. Wound healing reaction was mild and no incidence of graft rejection occurred during the period of review. Preoperative topical steroid had been suggested to reduce the incidence of graft rejection, yet this was not a large problem in this series. These eyes did well with continuation of their baseline steroid dosage with a strong steroid four times daily for the first month after the LASIK procedure.

The timing of further refractive surgery may be debated. The minimum time for LASIK after all sutures had been removed in this study was 10 months. Our patients had their penetrating keratoplasty at least 23 months before LASIK. This report confirms that adequate wound integrity is present to prevent disruption of the corneal wound in the treated eyes. Other authors recommend waiting 2–3 years [40].

There were no problems of graft dehiscence on application of the microkeratome suction ring. Complications noted by other authors include bleeding into the interface after the keratome passed, locking of the keratome due to an old nylon corneal suture [9], and worsening of the refractive error [23]. One theoretical risk is that of inciting a rejection episode. This has not occurred so far, postoperative steroids probably contribute to ensuring against this.

In our series, we performed the procedure in one step to allow quicker visual rehabilitation and limit the potential for complications to one surgery if possible, because the rate of epithelial ingrowth as a complication is higher in enhancement procedures.

In this study, a detailed analysis of HOAs showed significant improvements in total HOAs and spherical aberrations 12 months after LASIK. These findings have not been reported in previous studies. In particular, we found that HOAs with spherical aberrations in 5-mm pupils significantly improved after Femto-LASIK.

Limitations of our study include the small number of patients, different patient ages, and different preoperative refraction of the patients. As TS LASIK and PTA LASIK have different indications, we believe a direct comparison in the same age group and similar refractive errors is not possible. In addition, a difference in wavefront errors may not be clinically meaningful, as it might be compensated for by the processing of the visual system.

The present study showed excellent safety data for ablation using the Zyoptix system. A great benefit of tissue-saving Femto-LASIK is the lower ablation depth needed per diopter of defocus equivalent, which creates a greater safety margin for the refractive surgeon in the prevention of keratectasia. Further studies involving groups of patients with different degrees of myopia and hyperopia are needed to evaluate the advantages and disadvantages of Femto-LASIK for laser refractive surgery.

Conflict of interest None of the authors has a financial interest in the subject matter of this article.

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